

ETSI TS 136 213 V15.14.0 (2021-09)



**LTE;
Evolved Universal Terrestrial Radio Access (E-UTRA);
Physical layer procedures
(3GPP TS 36.213 version 15.14.0 Release 15)**

<https://standards.iteh.ai/catalog/standards/sist/3be368c7-157f-4801-b214-d3e903510e67/etsi-ts-136-213-v15-14-0-2021-09>



Reference

RTS/TSGR-0136213vfe0

Keywords

LTE

ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - APE 7112B
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° w061004871

Important notice

The present document can be downloaded from:

<http://www.etsi.org/standards-search>

The present document may be made available in electronic versions and/or in print. The content of any electronic and/or print versions of the present document shall not be modified without the prior written authorization of ETSI. In case of any existing or perceived difference in contents between such versions and/or in print, the prevailing version of an ETSI deliverable is the one made publicly available in PDF format at www.etsi.org/deliver.

Users of the present document should be aware that the document may be subject to revision or change of status.

Information on the current status of this and other ETSI documents is available at

<https://portal.etsi.org/TB/ETSIDeliverableStatus.aspx>

If you find errors in the present document, please send your comment to one of the following services:

<https://portal.etsi.org/People/CommitteeSupportStaff.aspx>

Notice of disclaimer & limitation of liability

The information provided in the present deliverable is directed solely to professionals who have the appropriate degree of experience to understand and interpret its content in accordance with generally accepted engineering or other professional standard and applicable regulations.

No recommendation as to products and services or vendors is made or should be implied.

No representation or warranty is made that this deliverable is technically accurate or sufficient or conforms to any law and/or governmental rule and/or regulation and further, no representation or warranty is made of merchantability or fitness for any particular purpose or against infringement of intellectual property rights.

In no event shall ETSI be held liable for loss of profits or any other incidental or consequential damages.

Any software contained in this deliverable is provided "AS IS" with no warranties, express or implied, including but not limited to, the warranties of merchantability, fitness for a particular purpose and non-infringement of intellectual property rights and ETSI shall not be held liable in any event for any damages whatsoever (including, without limitation, damages for loss of profits, business interruption, loss of information, or any other pecuniary loss) arising out of or related to the use of or inability to use the software.

Copyright Notification

No part may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm except as authorized by written permission of ETSI.

The content of the PDF version shall not be modified without the written authorization of ETSI.

The copyright and the foregoing restriction extend to reproduction in all media.

© ETSI 2021.
All rights reserved.

Intellectual Property Rights

Essential patents

IPRs essential or potentially essential to normative deliverables may have been declared to ETSI. The declarations pertaining to these essential IPRs, if any, are publicly available for **ETSI members and non-members**, and can be found in ETSI SR 000 314: "*Intellectual Property Rights (IPRs); Essential, or potentially Essential, IPRs notified to ETSI in respect of ETSI standards*", which is available from the ETSI Secretariat. Latest updates are available on the ETSI Web server (<https://ipr.etsi.org/>).

Pursuant to the ETSI Directives including the ETSI IPR Policy, no investigation regarding the essentiality of IPRs, including IPR searches, has been carried out by ETSI. No guarantee can be given as to the existence of other IPRs not referenced in ETSI SR 000 314 (or the updates on the ETSI Web server) which are, or may be, or may become, essential to the present document.

Trademarks

The present document may include trademarks and/or tradenames which are asserted and/or registered by their owners. ETSI claims no ownership of these except for any which are indicated as being the property of ETSI, and conveys no right to use or reproduce any trademark and/or tradename. Mention of those trademarks in the present document does not constitute an endorsement by ETSI of products, services or organizations associated with those trademarks.

DECT™, **PLUGTESTS™**, **UMTS™** and the ETSI logo are trademarks of ETSI registered for the benefit of its Members. **3GPP™** and **LTE™** are trademarks of ETSI registered for the benefit of its Members and of the 3GPP Organizational Partners. **oneM2M™** logo is a trademark of ETSI registered for the benefit of its Members and of the oneM2M Partners. **GSM®** and the GSM logo are trademarks registered and owned by the GSM Association.

ITih STANDARD PREVIEW
(standards.itech.ai)

Legal notice

This Technical Specification (TS) has been produced by the ETSI 3rd Generation Partnership Project (3GPP).
<http://standards.itech.ai/catalog/standards/sst/36c500c7-197f-4601-b211-d3e903510e67/etsi-ts-136-213-v15-14-0-2021-09>

The present document may refer to technical specifications or reports using their 3GPP identities. These shall be interpreted as being references to the corresponding ETSI deliverables.

The cross reference between 3GPP and ETSI identities can be found under <http://webapp.etsi.org/key/queryform.asp>.

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the [ETSI Drafting Rules](#) (Verbal forms for the expression of provisions).

"**must**" and "**must not**" are **NOT** allowed in ETSI deliverables except when used in direct citation.

Contents

Intellectual Property Rights	2
Legal notice	2
Modal verbs terminology.....	2
Foreword.....	8
1 Scope	9
2 References	9
3 Symbols and abbreviations.....	10
3.1 Symbols.....	10
3.2 Abbreviations	10
4 Synchronization procedures	12
4.1 Cell search	12
4.2 Timing synchronization.....	12
4.2.1 Radio link monitoring.....	12
4.2.2 Inter-cell synchronization	12
4.2.3 Transmission timing adjustments	12
4.3 Timing for Secondary Cell Activation / Deactivation	14
5 Power control	15
5.1 Uplink power control.....	15
5.1.1 Physical uplink shared channel	15
5.1.1.1 UE behaviour	16
5.1.1.2 Power headroom	30
5.1.2 Physical uplink control channel.....	33
5.1.2.1 UE behaviour	34
5.1.3 Sounding Reference Symbol (SRS).....	39
5.1.3.1 UE behaviour	39
5.1.3.2 Power headroom for Type3 report.....	41
5.1.4 Power allocation for EUTRA dual connectivity	42
5.1.4.1 Dual connectivity power control Mode 1.....	43
5.1.4.2 Dual connectivity power control Mode 2.....	50
5.1.5 Power allocation for PUCCH-SCell	54
5.2 Downlink power allocation	55
5.2.1 eNodeB Relative Narrowband TX Power (RNTP) restrictions	58
6 Random access procedure	59
6.1 Physical non-synchronized random access procedure.....	59
6.1.1 Timing	60
6.2 Random Access Response Grant.....	61
7 Physical downlink shared channel related procedures	66
7.1 UE procedure for receiving the physical downlink shared channel	67
7.1.1 Single-antenna port scheme	86
7.1.2 Transmit diversity scheme	86
7.1.3 Large delay CDD scheme	86
7.1.4 Closed-loop spatial multiplexing scheme	86
7.1.5 Multi-user MIMO scheme	87
7.1.5A Dual layer scheme.....	87
7.1.5B Up to 8 layer transmission scheme	87
7.1.6 Resource allocation.....	87
7.1.6.1 Resource allocation type 0	89
7.1.6.2 Resource allocation type 1	90
7.1.6.3 Resource allocation type 2	91
7.1.6.4 PDSCH starting position	94
7.1.6.4A PDSCH starting position for BL/CE UEs	96
7.1.6.5 Physical Resource Block (PRB) bundling.....	96

7.1.7	Modulation order and transport block size determination	98
7.1.7.1	Modulation order and redundancy version determination.....	100
7.1.7.2	Transport block size determination	106
7.1.7.2.1	Transport blocks not mapped to two or more layer spatial multiplexing	111
7.1.7.2.2	Transport blocks mapped to two-layer spatial multiplexing.....	119
7.1.7.2.3	Transport blocks mapped for DCI Format 1C and DCI Format 6-2.....	119
7.1.7.2.4	Transport blocks mapped to three-layer spatial multiplexing.....	120
7.1.7.2.5	Transport blocks mapped to four-layer spatial multiplexing.....	120
7.1.7.2.6	Transport blocks mapped for BL/CE UEs configured with CEModeB and PDSCH bandwidth up to 1.4MHz.....	121
7.1.7.2.7	Transport blocks mapped for BL/CE UEs <i>SystemInformationBlockType1-BR</i>	122
7.1.7.2.8	Transport blocks mapped for UEs configured with <i>ce-pdsch-maxBandwidth-config</i> value of 5 MHz or with <i>pdsch-MaxBandwidth-SC-MTCH</i> value of 24 PRBs	122
7.1.7.3	Redundancy Version determination for Format 1C	122
7.1.8	Storing soft channel bits	123
7.1.9	PDSCH resource mapping parameters.....	123
7.1.10	Antenna ports quasi co-location for PDSCH	125
7.1.11	PDSCH subframe assignment for BL/CE UE.....	126
7.2	UE procedure for reporting Channel State Information (CSI)	128
7.2.1	Aperiodic CSI Reporting using PUSCH.....	138
7.2.2	Periodic CSI Reporting using PUCCH	164
7.2.3	Channel Quality Indicator (CQI) definition.....	204
7.2.4	Precoding Matrix Indicator (PMI) definition	218
7.2.5	Channel-State Information – Reference Signal (CSI-RS) definition	246
7.2.6	Channel-State Information – Interference Measurement (CSI-IM) Resource definition.....	248
7.2.7	Zero Power CSI-RS Resource definition	248
7.2.8	CSI-RS Activation / Deactivation	248
7.3	UE procedure for reporting HARQ-ACK	249
7.3.1	FDD HARQ-ACK reporting procedure.....	251
7.3.2	TDD HARQ-ACK reporting procedure.....	256
7.3.2.1	TDD HARQ-ACK reporting procedure for same UL/DL configuration	257
7.3.2.2	TDD HARQ-ACK reporting procedure for different UL/DL configurations	272
7.3.3	FDD-TDD HARQ-ACK reporting procedure for primary cell frame structure type 1.....	279
7.3.4	FDD-TDD HARQ-ACK reporting procedure for primary cell frame structure type 2.....	281
8	Physical uplink shared channel related procedures	283
8.0	UE procedure for transmitting the physical uplink shared channel.....	283
8.0.1	Single-antenna port scheme	309
8.0.2	Closed-loop spatial multiplexing scheme	309
8.1	Resource allocation for PDCCH/EPDCCH/SPDCCH with uplink DCI format.....	310
8.1.1	Uplink resource allocation type 0	310
8.1.2	Uplink resource allocation type 1	311
8.1.3	Uplink resource allocation type 2	311
8.1.4	Uplink resource allocation type 3	312
8.1.5	Uplink resource allocation type 4	313
8.1.5.1	UL Resource Block Groups	313
8.1.6	Uplink resource allocation type 5	314
8.2	UE sounding procedure	316
8.3	UE HARQ-ACK procedure.....	327
8.3A	Autonomous uplink feedback procedure.....	329
8.4	UE PUSCH hopping procedure.....	329
8.4.1	Type 1 PUSCH hopping	330
8.4.2	Type 2 PUSCH hopping	330
8.5	UE Reference Symbol (RS) procedure.....	331
8.6	Modulation order, redundancy version and transport block size determination.....	332
8.6.1	Modulation order and redundancy version determination	332
8.6.2	Transport block size determination.....	340
8.6.3	Control information MCS offset determination.....	346
8.7	UE transmit antenna selection	350
8.8	Transmission timing adjustments	350
9	Physical downlink control channel procedures	350

9.1	UE procedure for determining physical downlink control channel assignment	351
9.1.1	PDCCH assignment procedure	351
9.1.2	PHICH assignment procedure.....	355
9.1.3	Control Format Indicator (CFI) assignment procedure.....	358
9.1.4	EPDCCH assignment procedure.....	359
9.1.4.1	EPDCCH starting position	366
9.1.4.2	Antenna ports quasi co-location for EPDCCH.....	366
9.1.4.3	Resource mapping parameters for EPDCCH	367
9.1.4.4	PRB-pair indication for EPDCCH	367
9.1.5	MPDCCH assignment procedure.....	368
9.1.5.1	MPDCCH starting position	375
9.1.5.2	Antenna ports quasi co-location for MPDCCH	375
9.1.6	SPDCCH assignment procedure	375
9.1.6.1	Resource mapping parameters for SPDCCH	377
9.1.6.2	PRB-pair indication for SPDCCH.....	377
9.1.6.3	Physical Resource Block (PRB) bundling for DMRS-based SPDCCH	378
9.1.6.4	Antenna ports quasi co-location for DMRS-based SPDCCH	378
9.2	PDCCH/EPDCCH/MPDCCH/SPDCCH validation for semi-persistent scheduling.....	379
9.2A	PDCCH/EPDCCH validation for autonomous uplink transmissions	381
9.3	PDCCH/EPDCCH/MPDCCH/SPDCCH control information procedure	382
10	Physical uplink control channel procedures	383
10.1	UE procedure for determining physical uplink control channel assignment.....	384
10.1.1	PUCCH format information.....	389
10.1.2	FDD HARQ-ACK feedback procedures.....	395
10.1.2.1	FDD HARQ-ACK procedure for one configured serving cell.....	395
10.1.2.2	FDD HARQ-ACK procedures for more than one configured serving cell	399
10.1.2.2.1	PUCCH format 1b with channel selection HARQ-ACK procedure.....	399
10.1.2.2.2	PUCCH format 3 HARQ-ACK procedure	403
10.1.2.2.3	PUCCH format 4 HARQ-ACK procedure	405
10.1.2.2.4	PUCCH format 5 HARQ-ACK procedure	408
10.1.3	TDD HARQ-ACK feedback procedures	409
10.1.3.1	TDD HARQ-ACK procedure for one configured serving cell.....	411
10.1.3.2	TDD HARQ-ACK procedure for more than one configured serving cell.....	425
10.1.3.2.1	PUCCH format 1b with channel selection HARQ-ACK procedure.....	425
10.1.3.2.2	PUCCH format 3 HARQ-ACK procedure	441
10.1.3.2.3	PUCCH format 4 HARQ-ACK procedure	448
10.1.3.2.4	PUCCH format 5 HARQ-ACK procedure	465
10.1.3A	FDD-TDD HARQ-ACK feedback procedures for primary cell frame structure type 2	465
10.1.4	HARQ-ACK Repetition procedure.....	467
10.1.5	Scheduling Request (SR) procedure	468
10.2	Uplink HARQ-ACK timing	470
11	Physical Multicast Channel (PMCH) related procedures.....	475
11.1	UE procedure for receiving the PMCH	475
11.2	UE procedure for receiving MCCH and system information change notification.....	476
12	Assumptions independent of physical channel.....	476
13	Uplink/Downlink configuration determination procedure for Frame Structure Type 2.....	476
13.1	UE procedure for determining eIMTA-uplink/downlink configuration.....	477
13A	Subframe configuration for Frame Structure Type 3	478
14	UE procedures related to Sidelink.....	481
14.1	Physical Sidelink Shared Channel related procedures.....	482
14.1.1	UE procedure for transmitting the PSSCH	482
14.1.1.1	UE procedure for determining subframes for transmitting PSSCH for sidelink transmission mode 1	484
14.1.1.1.1	Determination of subframe indicator bitmap.....	484
14.1.1.2	UE procedure for determining resource blocks for transmitting PSSCH for sidelink transmission mode 1.....	487
14.1.1.2.1	PSSCH resource allocation for sidelink transmission mode 1	487
14.1.1.2.2	PSSCH frequency hopping for sidelink transmission mode 1	488

14.1.1.3	UE procedure for determining subframes for transmitting PSSCH for sidelink transmission mode 2	488
14.1.1.4	UE procedure for determining resource blocks for transmitting PSSCH for sidelink transmission mode 2	489
14.1.1.4A	UE procedure for determining subframes and resource blocks for transmitting PSSCH for sidelink transmission mode 3	489
14.1.1.4B	UE procedure for determining subframes and resource blocks for transmitting PSSCH and reserving resources for sidelink transmission mode 4	490
14.1.1.4C	UE procedure for determining subframes and resource blocks for PSSCH transmission associated with an SCI format 1	490
14.1.1.5	UE procedure for PSSCH power control	491
14.1.1.6	UE procedure for determining the subset of resources to be reported to higher layers in PSSCH resource selection in sidelink transmission mode 4 and in sensing measurement in sidelink transmission mode 3	493
14.1.1.7	Conditions for selecting resources when the number of HARQ transmissions is two in sidelink transmission mode 4	496
14.1.2	UE procedure for receiving the PSSCH	497
14.1.3	UE procedure for determining resource block pool and subframe pool for sidelink transmission mode 2	497
14.1.5	UE procedure for determining resource block pool and subframe pool for sidelink transmission mode 3 and 4	498
14.2	Physical Sidelink Control Channel related procedures	499
14.2.1	UE procedure for transmitting the PSCCH	499
14.2.1.1	UE procedure for determining subframes and resource blocks for transmitting PSCCH for sidelink transmission mode 1	502
14.2.1.2	UE procedure for determining subframes and resource blocks for transmitting PSCCH for sidelink transmission mode 2	503
14.2.1.3	UE procedure for PSCCH power control	503
14.2.2	UE procedure for receiving the PSCCH	504
14.2.3	UE procedure for determining resource block pool and subframe pool for PSCCH	504
14.2.4	UE procedure for determining resource block pool for PSCCH in sidelink transmission mode 3 and 4	505
15	Void	509
16	UE Procedures related to narrowband IoT	509
16.1	Synchronization procedures	509
16.1.1	Cell search	509
16.1.2	Timing synchronization	509
16.2	Power control	510
16.2.1	Uplink power control	510
16.2.1.1	Narrowband physical uplink shared channel	510
16.2.1.1.1	UE behaviour	510
16.2.1.1.2	Power headroom	511
16.2.1.2	SR	511
16.2.1.2.1	UE behaviour	511
16.2.2	Downlink power allocation	511
16.3	Random access procedure	512
16.3.1	Physical non-synchronized random access procedure	512
16.3.2	Timing	513
16.3.3	Narrowband random access response grant	514
16.4	Narrowband physical downlink shared channel related procedures	515
16.4.1	UE procedure for receiving the narrowband physical downlink shared channel	516
16.4.1.1	Single-antenna port scheme	519
16.4.1.2	Transmit diversity scheme	519
16.4.1.3	Resource allocation	519
16.4.1.4	NPDSCH starting position	522
16.4.1.5	Modulation order and transport block size determination	523
16.4.1.5.1	Transport blocks not mapped for <i>SystemInformationBlockType1-NB</i>	523
16.4.1.5.2	Transport blocks mapped for <i>SystemInformationBlockType1-NB</i>	524
16.4.2	UE procedure for reporting ACK/NACK	524
16.5	Narrowband physical uplink shared channel related procedures	525

16.5.1	UE procedure for transmitting format 1 narrowband physical uplink shared channel.....	525
16.5.1.1	Resource allocation	527
16.5.1.2	Modulation order, redundancy version and transport block size determination.....	528
16.5.2	UE procedure for NPUSCH retransmission.....	530
16.5.3	UE procedure for transmitting SR	530
16.6	Narrowband physical downlink control channel related procedures.....	530
16.6.1	NPDCCH starting position	535
16.6.2	NPDCCH control information procedure	536
16.6.3	NPDCCH validation for semi-persistent scheduling	536
16.7	Assumptions independent of physical channel related to narrowband IoT	536
16.8	UE procedure for acquiring cell-specific reference signal sequence and raster offset	537
16.9	UE procedure for receiving narrowband wake up signal	537
17	Wake-up signal related procedures for BL/CE UE	538
Annex A (informative): Change history		539
History		558

iTeh STANDARD PREVIEW (standards.iteh.ai)

ETSI TS 136 213 V15.14.0 (2021-09)

<https://standards.iteh.ai/catalog/standards/sist/3be368c7-157f-4801-b214-d3e903510e67/etsi-ts-136-213-v15-14-0-2021-09>

Foreword

This Technical Specification (TS) has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of this present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

- x the first digit:
 - 1 presented to TSG for information;
 - 2 presented to TSG for approval;
 - 3 or greater indicates TSG approved document under change control.
- y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.
- z the third digit is incremented when editorial only changes have been incorporated in the document.

iTeh STANDARD PREVIEW
(standards.iteh.ai)

ETSI TS 136 213 V15.14.0 (2021-09)
<https://standards.iteh.ai/catalog/standards/sist/3be368c7-157f-4801-b214-d3e903510e67/etsi-ts-136-213-v15-14-0-2021-09>

1 Scope

The present document specifies and establishes the characteristics of the physical layer procedures in the FDD and TDD modes of E-UTRA.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

- [1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".
- [2] 3GPP TS 36.201: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical Layer – General Description".
- [3] 3GPP TS 36.211: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical channels and modulation".
- [4] 3GPP TS 36.212: "Evolved Universal Terrestrial Radio Access (E-UTRA); Multiplexing and channel coding".
- [5] 3GPP TS 36.214: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer – Measurements".
- [6] 3GPP TS 36.101: "Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio transmission and reception".
- [7] 3GPP TS 36.104: "Evolved Universal Terrestrial Radio Access (E-UTRA); Base Station (BS) radio transmission and reception".
- [8] 3GPP TS 36.321, "Evolved Universal Terrestrial Radio Access (E-UTRA); Medium Access Control (MAC) protocol specification".
- [9] 3GPP TS 36.423, "Evolved Universal Terrestrial Radio Access (E-UTRA); X2 Application Protocol (X2AP)".
- [10] 3GPP TS 36.133, "Evolved Universal Terrestrial Radio Access (E-UTRA); Requirements for support of radio resource management".
- [11] 3GPP TS 36.331, "Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC) protocol specification".
- [12] 3GPP TS 36.306: "Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio access capabilities".
- [13] 3GPP TS 37.213: "Physical layer procedures for shared spectrum channel access".
- [14] 3GPP TS 36.304: "Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) procedures in idle mode".
- [15] 3GPP TS 38.321: "NR; Medium Access Control (MAC) protocol specification"
- [16] 3GPP TS 38.133: "NR; Requirements for support of radio resource management"

3 Symbols and abbreviations

3.1 Symbols

For the purposes of the present document, the following symbols apply:

n_f	System frame number as defined in [3]
n_s	Slot number within a radio frame as defined in [3]
N_{cells}^{DL}	Number of configured cells
N_{RB}^{DL}	Downlink bandwidth configuration, expressed in units of N_{sc}^{RB} as defined in [3]
N_{RB}^{UL}	Uplink bandwidth configuration, expressed in units of N_{sc}^{RB} as defined in [3]
N_{symb}^{UL}	Number of SC-FDMA symbols in an uplink slot as defined in [3]
N_{sc}^{RB}	Resource block size in the frequency domain, expressed as a number of subcarriers as defined in [3]
T_s	Basic time unit as defined in [3]

3.2 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in TR 21.905 [1].

ACK	Acknowledgement
AUL	Autonomous Uplink
AUL-DFI	AUL downlink feedback information
BCH	Broadcast Channel
CCE	Control Channel Element
CDD	Cyclic Delay Diversity
CG	Cell Group
CIF	Carrier Indicator Field
CQI	Channel Quality Indicator
CRC	Cyclic Redundancy Check
CRI	CSI-RS Resource Indicator
CSI	Channel State Information
CSI-IM	CSI-interference measurement
DAI	Downlink Assignment Index
DC	Dual Connectivity
DCI	Downlink Control Information
DL	Downlink
DL-SCH	Downlink Shared Channel
DTX	Discontinuous Transmission
EDT	Early Data Transmission
EN-DC	E-UTRA NR Dual Connectivity with MCG using E-UTRA and SCG using NR
EPDCCH	Enhanced Physical Downlink Control Channel
EPRE	Energy Per Resource Element
MCG	Master Cell Group
MCS	Modulation and Coding Scheme
NACK	Negative Acknowledgement
NE-DC	NR E-UTRA Dual Connectivity with MCG using NR and SCG using E-UTRA
NPBCH	Narrowband Physical Broadcast CHannel
NPDCCH	Narrowband Physical Downlink Control CHannel
NPDSCH	Narrowband Physical Downlink Shared CHannel
NPRACH	Narrowband Physical Random Access CHannel
NPUSCH	Narrowband Physical Uplink Shared CHannel
NPSS	Narrowband Primary Synchronization Signal
NSSS	Narrowband Secondary Synchronization Signal

NRS	Narrowband Reference Signal
PBCH	Physical Broadcast Channel
PCFICH	Physical Control Format Indicator Channel
PDCCH	Physical Downlink Control Channel
PDSCH	Physical Downlink Shared Channel
PHICH	Physical Hybrid ARQ Indicator Channel
PMCH	Physical Multicast Channel
PMI	Precoding Matrix Indicator
PRACH	Physical Random Access Channel
PRS	Positioning Reference Signal
PRB	Physical Resource Block
PSBCH	Physical Sidelink Broadcast Channel
PSCCH	Physical Sidelink Control Channel
PSCell	Primary Secondary cell
PSDCH	Physical Sidelink Discovery Channel
PSSCH	Physical Sidelink Shared Channel
PSSS	Primary Sidelink Synchronisation Signal
PUCCH	Physical Uplink Control Channel
PUCCH-SCell	PUCCH SCell
PUSCH	Physical Uplink Shared Channel
PTI	Precoding Type Indicator
RBG	Resource Block Group
RE	Resource Element
RI	Rank Indication
RS	Reference Signal
RSS	Resynchronization Signal
SCG	Secondary Cell Group
SINR	Signal to Interference plus Noise Ratio
SPS C-RNTI	Semi-Persistent Scheduling C-RNTI
SR	Scheduling Request
SRS	Sounding Reference Symbol
SSSS	Secondary Sidelink Synchronisation Signal
TAG	Timing Advance Group
TBS	Transport Block Size
UCI	Uplink Control Information
UE	User Equipment
UL	Uplink
UL-SCH	Uplink Shared Channel
VRB	Virtual Resource Block

4 Synchronization procedures

4.1 Cell search

Cell search is the procedure by which a UE acquires time and frequency synchronization with a cell and detects the physical layer Cell ID of that cell. E-UTRA cell search supports a scalable overall transmission bandwidth corresponding to 6 resource blocks and upwards.

The following signals are transmitted in the downlink to facilitate cell search: the primary and secondary synchronization signals.

A UE may assume the antenna ports 0 – 3 and the antenna port for the primary/secondary synchronization signals of a serving cell are quasi co-located (as defined in [3]) with respect to Doppler shift and average delay.

For a BL/CE UE, if the UE is configured with higher layer parameter *RSS-Config*, the UE can use the resynchronization signal (as defined in [3]) to re-acquire time and frequency synchronization with the cell.

4.2 Timing synchronization

4.2.1 Radio link monitoring

The downlink radio link quality of the primary cell shall be monitored by the UE for the purpose of indicating out-of-sync/in-sync status to higher layers.

If the UE is configured with a SCG [11] and the parameter *rlf-TimersAndConstantsSCG* is provided by the higher layers and is not set to release, the downlink radio link quality of the PSCell [11] of the SCG shall be monitored by the UE for the purpose of indicating out-of-sync/in-sync status to higher layers.

In non-DRX mode operation, the physical layer in the UE shall every radio frame assess the radio link quality, evaluated over the previous time period defined in [10], against thresholds (Q_{out} and Q_{in}) defined by relevant tests in [10].

In DRX mode operation, the physical layer in the UE shall at least once every DRX period assess the radio link quality, evaluated over the previous time period defined in [10], against thresholds (Q_{out} and Q_{in}) defined by relevant tests in [10].

If higher-layer signalling indicates certain subframes for restricted radio link monitoring, the radio link quality shall not be monitored in any subframe other than those indicated.

The physical layer in the UE shall in radio frames where the radio link quality is assessed indicate out-of-sync to higher layers when the radio link quality is worse than the threshold Q_{out} . When the radio link quality is better than the threshold Q_{in} , the physical layer in the UE shall in radio frames where the radio link quality is assessed indicate in-sync to higher layers.

4.2.2 Inter-cell synchronization

No functionality is specified in this subclause in this release.

4.2.3 Transmission timing adjustments

Upon reception of a timing advance command or a timing adjustment indication for a TAG containing the primary cell or PSCell, the UE shall adjust uplink transmission timing for PUCCH/PUSCH/SRS of the primary cell or PSCell based on the received timing advance command or a timing adjustment indication.

The UL transmission timing for PUSCH/SRS of a secondary cell is the same as the primary cell if the secondary cell and the primary cell belong to the same TAG. If the primary cell in a TAG has a frame structure type 1 and a secondary cell in the same TAG has a frame structure type 2 or frame structure 3, UE may assume that $N_{TA} \geq 624$.

If the UE is configured with a SCG, the UL transmission timing for PUSCH/SRS of a secondary cell other than the PSCell is the same as the PSCell if the secondary cell and the PSCell belong to the same TAG.

Upon reception of a timing advance command or a timing adjustment indication for a TAG not containing the primary cell or PSCell, if all the serving cells in the TAG have the same frame structure type, the UE shall adjust uplink transmission timing for PUSCH/SRS of all the secondary cells in the TAG based on the received timing advance command or a timing adjustment indication where the UL transmission timing for PUSCH /SRS is the same for all the secondary cells in the TAG.

Upon reception of a timing advance command or a timing adjustment indication for a TAG not containing the primary cell or PSCell, if a serving cell in the TAG has a different frame structure type compared to the frame structure type of another serving cell in the same TAG, the UE shall adjust uplink transmission timing for PUSCH/SRS of all the secondary cells in the TAG by using $N_{TAOffset} = 624$ regardless of the frame structure type of the serving cells and based on the received timing advance command or a timing adjustment indication where the UL transmission timing for PUSCH /SRS is the same for all the secondary cells in the TAG. $N_{TAOffset}$ is described in [3].

The timing adjustment indication specified in [11] indicates the initial N_{TA} used for a TAG. The timing advance command for a TAG indicates the change of the uplink timing relative to the current uplink timing for the TAG as multiples of $16 T_s$. The start timing of the random access preamble is specified in [3].

In case of random access response, an 11-bit timing advance command [8], T_A , for a TAG indicates N_{TA} values by index values of $T_A = 0, 1, 2, \dots, 256$ if the UE is configured with a SCG, and $T_A = 0, 1, 2, \dots, 1282$ otherwise, where an amount of the time alignment for the TAG is given by $N_{TA} = T_A \times 16$. N_{TA} is defined in [3].

In other cases, a 6-bit timing advance command [8], T_A , for a TAG indicates adjustment of the current N_{TA} value, $N_{TA,old}$, to the new N_{TA} value, $N_{TA,new}$, by index values of $T_A = 0, 1, 2, \dots, 63$, where $N_{TA,new} = N_{TA,old} + (T_A - 31) \times 16$. Here, adjustment of N_{TA} value by a positive or a negative amount indicates advancing or delaying the uplink transmission timing for the TAG by a given amount respectively.

For a non-BL/CE UE, for a timing advance command received on

- subframe n , the corresponding adjustment of the uplink transmission timing shall apply from the beginning of subframe $n+5$ if the UE is configured with higher layer parameter *shortProcessingTime* and the corresponding PDCCH with CRC scrambled by C-RNTI is in the UE-specific search space, $n+6$ otherwise.
- slot n , the corresponding adjustment of the uplink transmission timing shall apply from the first subframe boundary no earlier than slot $[n+8]$
- subslot n , the corresponding adjustment of the uplink transmission timing shall apply from the first subframe boundary no earlier than
 - subslot $[n+16]$ if higher layer parameter *proc-TimeAdv-r15* = 'nplus4set1'.
 - subslot $[n+18]$ if higher layer parameter *proc-TimeAdv-r15* = 'nplus6set1' or 'nplus6set2'.
 - subslot $[n+20]$ if higher layer parameter *proc-TimeAdv-r15* = 'nplus8set2'.

For serving cells in the same TAG, when the UE's uplink PUCCH/PUSCH/SRS transmissions in subframe n and subframe $n+1$ are overlapped due to the timing adjustment, the UE shall complete transmission of subframe n and not transmit the overlapped part of subframe $n+1$.

For a BL/CE UE, for a timing advance command received on subframe n , the corresponding adjustment of the uplink transmission timing shall apply for the uplink PUCCH/PUSCH/SRS transmissions in subframe $n+6$. When the BL/CE UE's uplink PUCCH/PUSCH/SRS transmissions in subframe n and subframe $n+1$ are on the same narrowband and are overlapped due to the timing adjustment, the UE shall complete transmission of subframe n and is not required to transmit in subframe $n+1$ until the first available symbol that has no overlapping portion with subframe n . When the BL/CE UE's uplink PUCCH/PUSCH/SRS transmissions in subframe n and subframe $n+1$ are on different narrowbands, and the timing adjustment occurs in the guard period for narrowband retuning, the UE is not required to transmit in subframe $n+1$ until the first available symbol that has no overlapping portion with subframe n and which does not reduce the guard period.

If the received downlink timing changes and is not compensated or is only partly compensated by the uplink timing adjustment without timing advance command as specified in [10], the UE changes N_{TA} accordingly.

4.3 Timing for Secondary Cell Activation / Deactivation

When a UE receives an activation command [8] for a secondary cell in subframe n , the corresponding actions in [8] shall be applied no later than the minimum requirement defined in [10] and no earlier than subframe $n+8$, except for the following:

- the actions related to CSI reporting on a serving cell which is active in subframe $n+8$
- the actions related to the *sCellDeactivationTimer* associated with the secondary cell [8]

which shall be applied in subframe $n+8$.

- the actions related to CSI reporting on a serving cell which is not active in subframe $n+8$

which shall be applied in the earliest subframe after $n+8$ in which the serving cell is active.

When a UE receives an RRC configuration which configures secondary cell as activated [11] in subframe n , the corresponding actions in [8] shall be applied no later than the minimum requirement defined in [10] and no earlier than subframe $n+20$, except for the following:

- the actions related to CSI reporting on a serving cell which is active in subframe $n+20$
- the actions related to the *sCellDeactivationTimer* associated with the secondary cell [8]

which shall be applied in subframe $n+20$.

- the actions related to CSI reporting on a serving cell which is not active in subframe $n+20$

which shall be applied in the earliest subframe after $n+20$ in which the serving cell is active.

If a UE has been configured with *cqi-ShortPeriodicSCell* for a secondary cell, parameters *cqi-pmi-ConfigIndex* and *ri-ConfigIndex* in clause 7.2 are given by *cqi-ShortPeriodicSCell* from subframe $n+8$ until subframe $n+34$.

When a UE receives a deactivation command [8] for a secondary cell or the *sCellDeactivationTimer* associated with the secondary cell expires in subframe n , the corresponding actions in [8] shall apply no later than the minimum requirement defined in [10], except for the actions related to CSI reporting on a serving cell which is active which shall be applied in subframe $n+8$.